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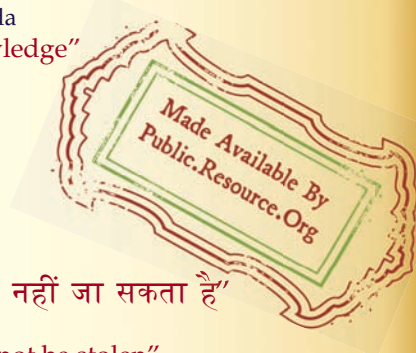
IS 13048 (1991): Recommendations for hydraulic design of duck bill spillways [WRD 9: Dams and Spillways]



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भारतीय मानक

डकबिल अधिप्रवाह मार्गों के जलीय
डिज़ाइन की सिफारिशें

Indian Standard

**RECOMMENDATIONS FOR HYDRAULIC
DESIGN OF DUCKBILL SPILLWAYS**

UDC 627.831

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Spillways Including Energy Dissipators Sectional Committee had been approved by the River Valley Division Council.

Discharging large floods can be accomplished by increasing either the spillway crest length or operating head. In practice increasing this head is achieved by using gated spillways. By this selection, it is possible to increase significantly the unit discharge of the crest. Therefore, if the crest and chute width are reduced, gated spillways may result in significant cost reduction over uncontrolled straight crests. When the spillway is located in remote area where electric power supply, man-power, etc, are scarce and/or the submergence in the upstream is not a problem, it is desirable to use an uncontrolled crest. To increase the crest length of uncontrolled spillways, in a comparatively small lateral space, different types of crest shapes have been developed. Three-sided spillways (rectangular or trapezoidal shape in plan), Y-shaped spillways and curved crest spillways are examples of such development (Fig. 1). The duckbill spillways is a three-sided spillway and projects into the reservoir water spread. The surplussing water flows over the sides and is collected in a gathering trough and conveyed through a chute on to a terminal structure which may be a stilling basin or a roller or ski-jump bucket. Series of duckbill spillway can be termed as labyrinth weir. The recommendations for hydraulic design of only duckbill spillway are given in this standard.

Ideally the discharge over the duckbill spillway should increase in direct proportion to an increase in total crest length. However, this is only applicable for spillway with low design head. As the upstream head over the crest increases and forms a solid and non-aerated nappe, the flow would be in a suppressed phase and efficiency of the spillway decreases approaching that of a straight crest with a length equal to the chute width. Hence duckbill spillway is advantageously provided where free flow exists. It is not recommended to provide this type of spillway where it would usually be subjected to operation under heavily drowned flow conditions. However, model studies are essential to check the efficiency of the spillway design.

This type of spillway can be economically located in the flanks of earth and rockfill dams as it results in a considerable reduction in the excavation, both in the approach and tail channel, when compared with straight spillways or side-channel spillways. This type of spillways may be advantageous where maximum allowable afflux is limited. It also increases storage capacity because the crest level can be fixed at higher level for the same maximum water level. On the other hand, as it can pass floods at lower head compared to normal weir, the MWL is lowered and consequently height of the dam can be reduced thus affecting a saving in cost of construction and reduction in the submergence.

Indian Standard

RECOMMENDATIONS FOR HYDRAULIC
DESIGN OF DUCKBILL SPILLWAYS

1 SCOPE

1.1 This standard recommends criteria to be adopted for the hydraulic design of duckbill spillways.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	Title
4997 : 1968	Criteria for design of hydraulic jump type stilling basins with horizontal and sloping apron
6934 : 1973	Recommendations for hydraulic design of high ogee overflow spillways
7365 : 1985	Criteria for hydraulic design of bucket type energy dissipators (first revision)

3 NOTATIONS

3.1 For the purpose of this standard the following notations shall have the meaning indicated against each (see Fig. 2).

L_n	= Theoretical length of normal straight spillway in m
L_{n1} and L_{n2} , etc	= The trial lengths of the duckbill spillway in m
C_n	= Coefficient of discharge for the normal straight spillway
Q	= Peak flood to be surplussed in cumecs
H_n	= Depth of flow over the normal straight spillway in m
Q_1, Q_2 , etc	= Discharge over the duckbill spillway corresponding to length L_{n1} , L_{n2} , etc, in cumecs
L_1 and L_2	= Dimension of the segments of the crest length
L	= Total length of duckbill spillway = $2L_1 + L_2$
L_d	= Length of disturbance of flow at the corners in case of polygonal shapes.
C_1	= Coefficient of reduction for the duckbill spillway to be applied for C_n

a and b	= Constants to be obtained from Fig. 3 and 4 for polygonal shape
	= Corner angle of the duckbill spillway
	= 90 degrees for rectangular

4 TERMINOLOGY

4.0 For the purpose of this standard, the following definitions shall apply.

4.1 Duckbill Spillway

This is a spillway with a rectangular layout projections into the reservoir comprising three straight overflow lengths intersecting at right angles. The layout could be trapezoidal in which case the corner angles will be other than 90 degree. The flow from the three reaches of the spillway interacts in the trough portion and is further conveyed through a discharge carrier on to a terminal structure to provide for energy dissipation.

4.2 Trough

The trough of the duckbill spillway is formed by the intersection of the downstream profiles of the three straight length.

5 PROFILE

5.1 Normally the crest profile formed of compound circular curve is adopted. However, the ogee profile, if provided, shall be in conformity with IS 6934 : 1973.

6 DISCHARGE COMPUTATIONS

6.1 The peak discharge Q for a normal straight spillway of length L_n with head H_n shall be computed from the equation:

$$Q = C_n L_n H_n^{3/2} \text{ based on the recommendations made in IS 6934 : 1973.}$$

6.2 The length of the duckbill spillway to pass the discharge Q at a head equal to H_n is determined as described below:

- Assume a trial length L_{n1} of the duckbill spillway greater than L_n .
- The length of disturbance L_d is determined as $L_d = \left(\frac{a}{1-b} \right)$. The values of a and b for various corner angles shall be obtained from Fig. 3 and 4.

- c) A reduction coefficient C_1 to account for the flow disturbance at the corners is computed as:

$$C_1 = 1 - \frac{2 Ld}{Ln_1}$$

- d) The discharge over the duckbill spillway of trial length Ln_1 is computed as $Q_1 = C_1 \times C_n \times Ln_1 \times Hn^{3/2}$.
- e) If the discharge Q_1 is less than Q then a second trial length Ln_2 greater than Ln_1 is assumed and Q_2 is determined as in (b) to (d) above and the length of the duckbill spillway ' L ' shall be obtained to pass the discharge Q .
- f) The total length ' L ' of the spillway so arrived at shall be adjusted such that $2L_1 + L_2 = L$ and L_2 shall not be less than $2 Ld$.

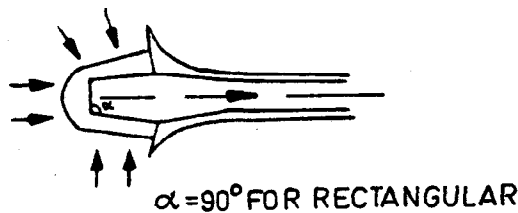
7 DISCHARGE CARRIER AND TERMINAL STRUCTURE

7.1 The discharge carrier shall be appropriately designed to convey the total spillway discharge Q , safely.

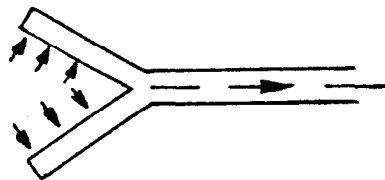
7.2 The terminal structure which may consist of either ski-jump bucket (see IS 7365 : 1985) or stilling basin (see IS 4997 : 1968) shall be suitably designed based on the hydraulic and geotechnical conditions at the site.

8 MODEL STUDIES

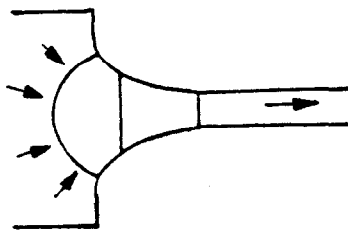
8.1 The design shall be tested on a hydraulic model to confirm the efficacy.



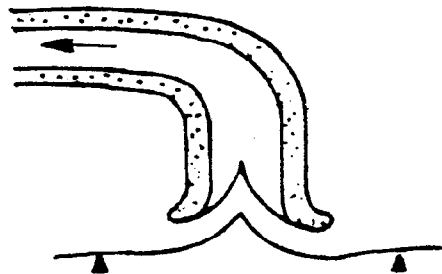
1A Three Sided Spillway



1B Y-Shaped Spillway



1C Curved Crest Spillway



1D Morning Glory Spillway

FIG. 1 TYPES OF SPILLWAY

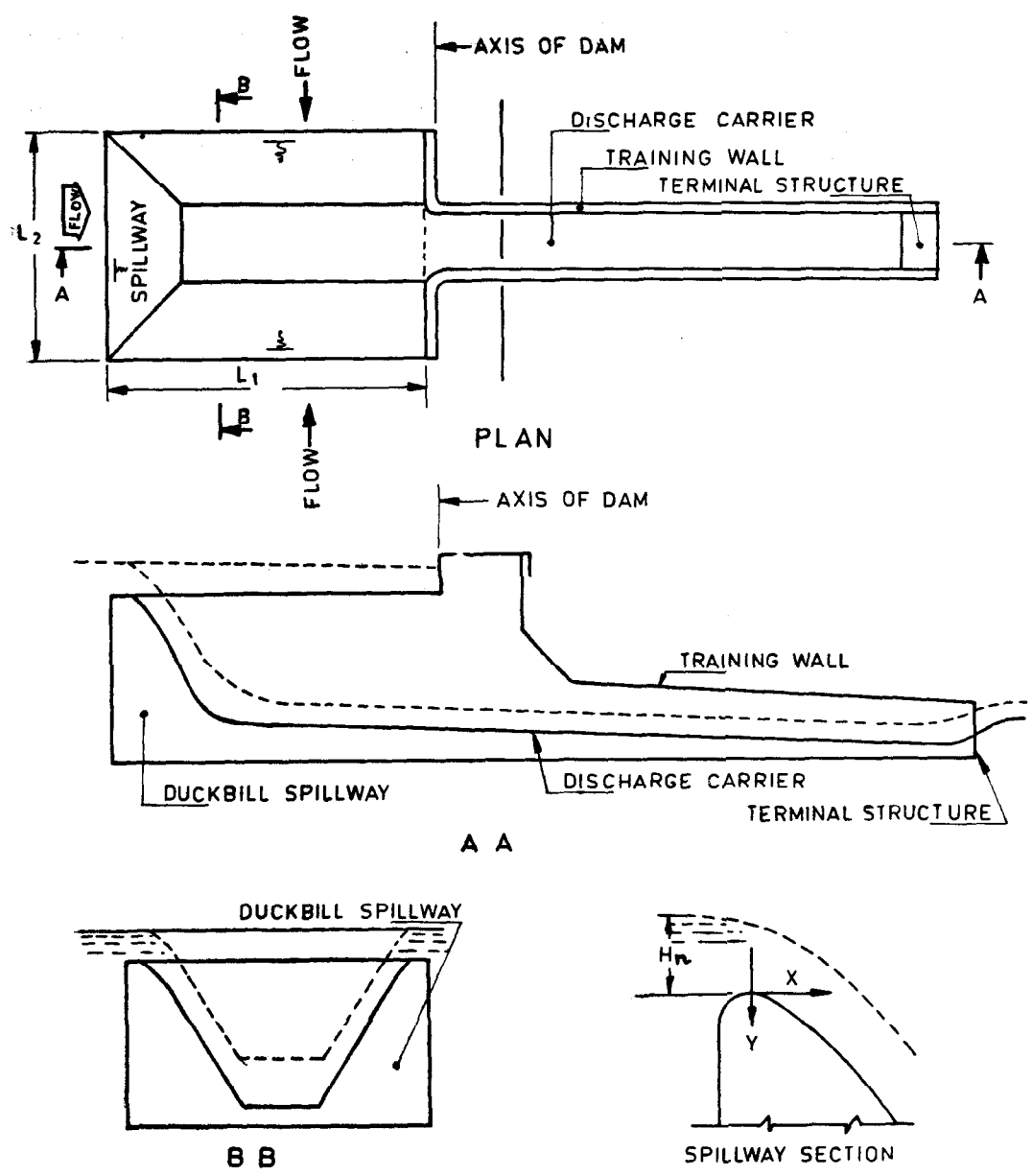


FIG. 2 DUCKBILL SPILLWAY

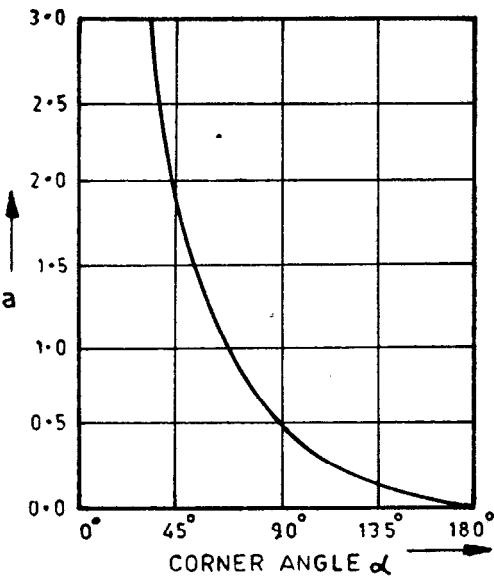


FIG. 3 CONSTANT 'a'

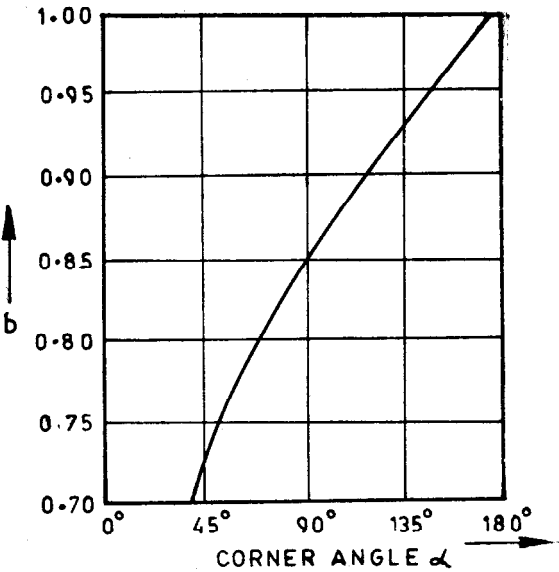


FIG. 4 CONSTANT 'b'

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